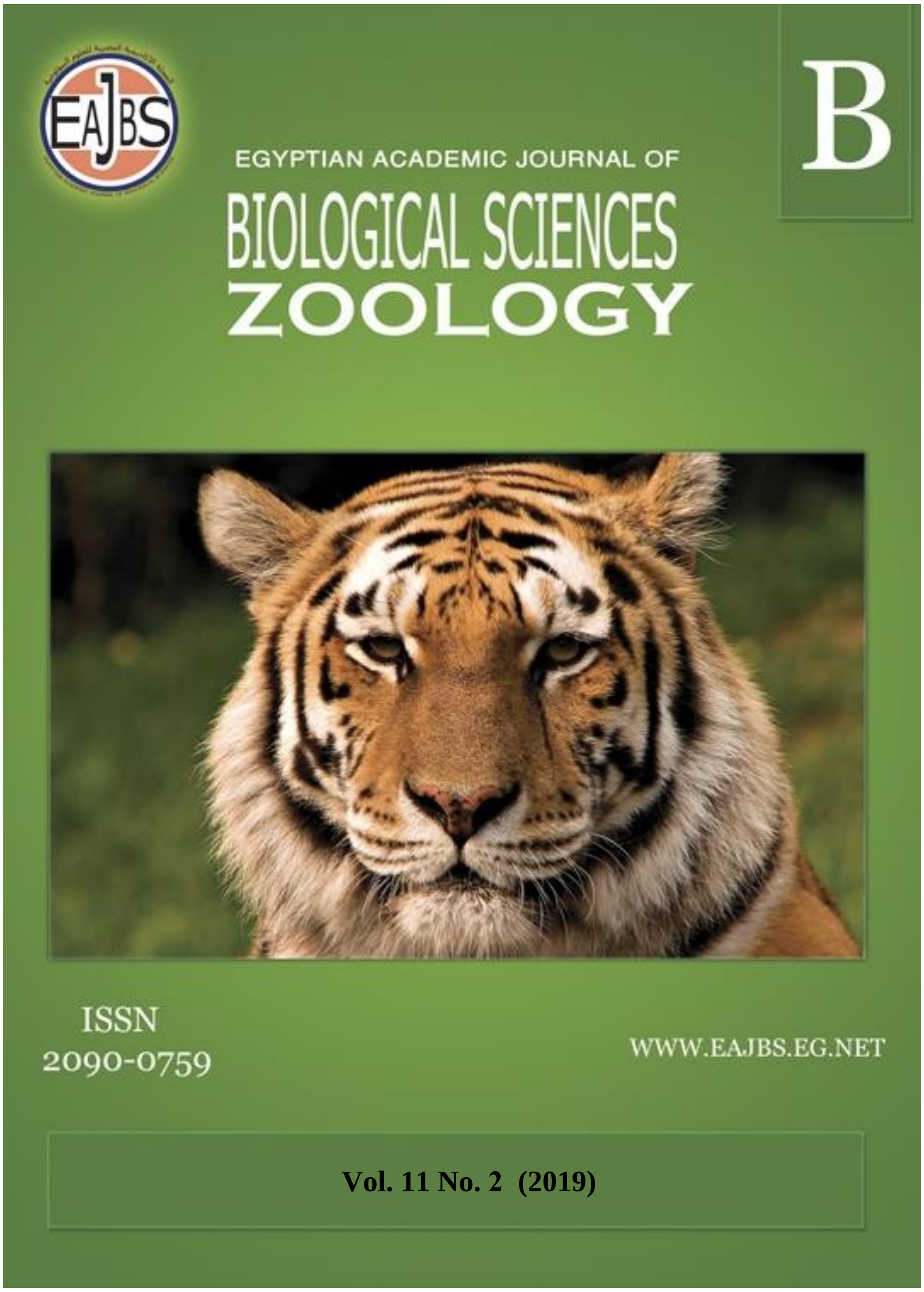

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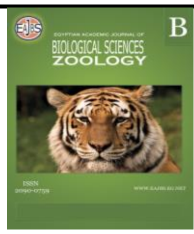

Elemental Composition of Plankton In The Atlantic Ocean off the Coast of Lagos, Nigeria.

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ABSTRACT

The determination of the elemental composition of plankton is important for interpretation of functional states of the aquatic ecosystems. The present study is focused on the elemental composition of the plankton assemblages from the Atlantic Ocean off the coast of Lagos, Nigeria using scanning electron microscope - SEM (VEGA3 TESCAN) coupled with energy dispersive x-ray spectrometry - EDS (Quantax 200, Bruker EDX) at an accelerating voltage of 5 - 20 kV. Surface plankton samples were collected by horizontal tows with a plankton net (55 µm pore mesh size) at approximately 15 km away from the seashore along the entire Lagos shoreline (180km). The result from the SEM/EDS technique showed that the plankton is composed majorly of 13 elements (O, C, Si, Al, Cl, Fe, Mg, Na, K, S, Ti, Ca and P). The mineral particles of calcium (0.2%), potassium (1.3%), sodium (1.5%), chlorine (5.0%), magnesium (1.8%) and iron (3.3%) as well as organogenic elements of oxygen (36.9%), carbon (27.8%), sulphur (1%) and phosphorus (0.2%) were quantified.

INTRODUCTION

Phytoplankton are functional groups of prokaryotic and eukaryotic organisms (Lopes dos Santos *et al.*, 2017) that inhabit near the water surface where there is sufficient light to support photosynthesis. Zooplankton on the other hand is a collection of animal forms of drifting organisms in both fresh and marine waters (Onyema and Okedoyin, 2017). Therefore, both phytoplankton and zooplankton standing crop per time constitute the plankton assemblage. The ecology of planktonic organisms is influenced by the elemental characterization of some trace metals such as Fe, Cu, Zn, Cd and Hg (Nekhoroshkov e*t al*., 2014). The ability of plankton to concentrate trace elements from its environment is used to indicate the level of aquatic pollution in different regions of the World Ocean (McCormick and Cairns, 1994). Elemental accumulation as a dynamic process in plankton depends on the concentration of elements in the environment and different processes induced by the environmental nutritional stress, which are determined by the functional state of each organism (Sheue *et al*., 2003). An earlier report of Leonova *et al*. (2013) showed that the plankton responds to the presence of heavy metals in aquatic environments, as well as upon that some metals inhibit and some stimulate the growth of organisms.

Goals and approaches to the study of the elemental concentration of plankton vary from one researcher to the other. For instance, Leonova *et al*., (2013) estimated the concentration of a wide range of elements in the White Sea zooplankton, phytoplankton and zooplankton from freshwater Siberia lakes (Leonova *et al*., 2006) and considered their accumulation capacity and involving into geochemical processes. The elemental content of the Black Sea plankton has now been studied for over 50 years (Vinogradova and Petkevich, 1967; Rozhanskaya, 1983; Saenko, 1992). Similarly, Nekhoroshkov e*t al*., (2014) documented the concentrations of 45 elements in the coastal phytoplankton communities of the Black Sea coastal area near Sevastopol, Ukraine while Yau e*t al*., (2016) investigated 16 cultured tropical microalgae species.

There is no known information on elemental identification and quantification of the plankton from Nigerian coastal waters hence, the aim of this study was to determine the elements that are embedded in the plankton of the Atlantic Ocean off the coast of Lagos, Nigeria. This will help to evaluate the nutritional properties of the plankton in this marine environment.

MATERIALS AND METHODS

Description of Study Site:

The Atlantic Ocean off the coast of Lagos borders Nigeria to the south (Fig. 1). It lies between Latitude 6°15'52.9"N and Longitude 4°05'49.4"E and falls within the Barrier Lagoon complex (200 km). It is a marine environment and salinity is a major factor in the growth of some organisms (Onyema and Akanmu, 2017). The study stations were approximately 15 km away from the seashore along the coastline between Badagry and Ibeju Lekki local government area in Lagos state, Nigeria. Ten sampling stations were chosen to cover the entire length of Lagos state in the ocean. The dominant ocean currents operating within the region include the Benguella, Guinea, Equatorial and the Equatorial countercurrents (Longhurst, 2006; Nwankwo and Onyema, 2003). The climate is the wet equatorial type influenced by nearness to the equator and in the Gulf of Guinea. The climate of the area as experienced in the Lagos metropolis is influenced by two air masses namely: the tropical maritime and tropical continental air masses.

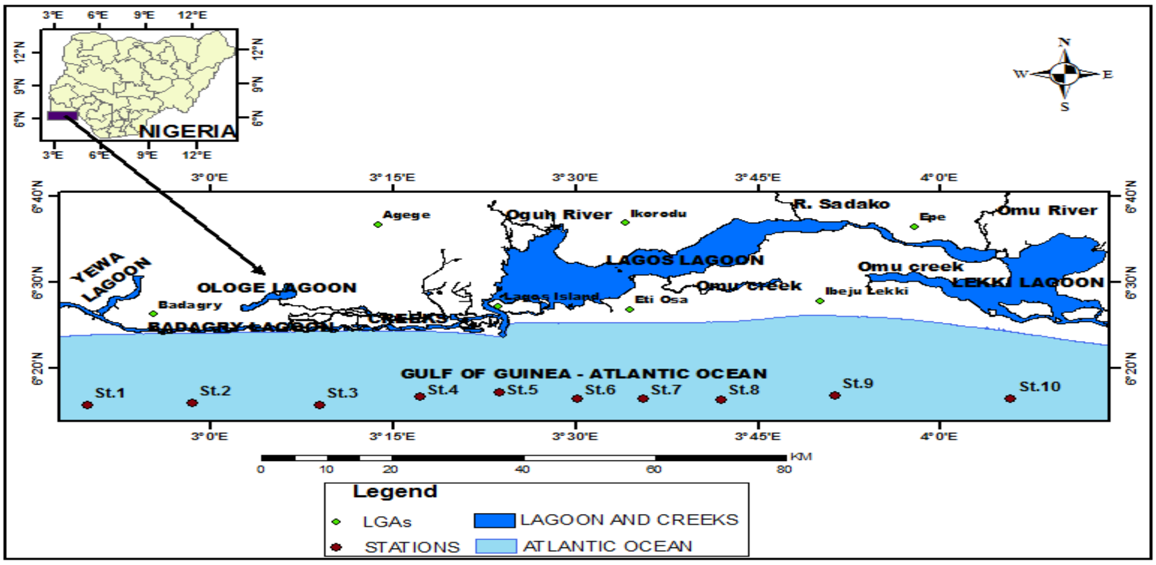

Fig. 1 The Coast off Lagos, Nigeria showing the Sampling Stations

Collection of Plankton Samples:

Plankton samples were collected at the ten stations in April, 2016 with a 55µm mesh size standard plankton net towed horizontally from a motorized boat for 5 minutes at low speed (<4 knots). The filtered plankton were emptied into well-labelled 250 ml plastic containers with screw caps.

Analysis of Plankton Samples:

0.5kg concentrated plankton sample without acid washing step were fixed in 2% glutaraldehyde ($C_5H_8O_2$) that was prepared in 0.1 M sodium cacodylate buffer ($C_2H_6AsNaO_2$) at pH 7.2 for 48 hours at 4 °C. Samples were filtered on paper filters with 10 µm pore size in the laboratory conditions. The sea-salt particles were dissolved and washed out after the treatment with distilled water. Then the filters with plankton were dried at room temperature. The samples were mounted on stubs using double-sticky tapes and then carbon (~10nm thick) coated at 20 mA for 180 s using sputter coater (BAL-TEC SCD005). Vacuum-evaporated carbon has a minimal influence on X-ray intensities on account of its low atomic number, and (unlike gold, which is commonly used for SEM specimens) does not add unwanted peaks to the X-ray spectrum. Samples were inserted into the working chamber for its elemental analysis at the reactor. Images of the samples were visualised and their elemental profiles were analysed using variable pressure scanning electron microscopy (model: VEGA3 TESCAN) at an accelerating voltage of 5 - 20 kV and a working distance of 7 - 15 mm. The microscope was coupled with energy dispersive X-ray spectrometry (Quantax 200, Bruker EDX) in order to obtain a distribution of elemental composition of the surface of plankton cell wall according to previously published data (Kania *et al*., 2009; Kaliski *et al*., 2012; Witek-Krowiak *et al*., 2013; Yau *et al*., 2016). The X-ray spectrum of the plankton loaded with a given microelement was obtained.

RESULTS

The plankton samples contain organic (phytoplankton, zooplankton and detritus) and inorganic particles. Therefore, scanning electron microscope (SEM/EDS) image showed aggregates of parts and tissues of plankton cells (Fig. 2) while diatoms of box and line shapes were revealed in SEM of plankton specimen (Fig. 3). A total of 13 elements in the order of oxygen (O), carbon (C), silicon (Si), aluminium (Al), chlorine (Cl), iron (Fe), magnesium (Mg), sodium (Na), potassium (K), sulphur (S), titanium (Ti), calcium (Ca) and phosphoru (P) were detected and distributed within the X-ray spectrum plankton (Fig. 4). In terms of percentage by weight of O, C, Si, Al, Cl, Fe, Mg, Na, K, S, Ti, Ca and P reported 37%, 28%, 14%, 7%, 5%, 3.3%, 1.8%, 1.5%, 1.3%, 1.0%, 0.3%, 0.2% and 0.2% respectively from the EDS. However, O, C, Si, Al, Cl and Fe were found to be higher than other elements comparatively (Fig. 5).

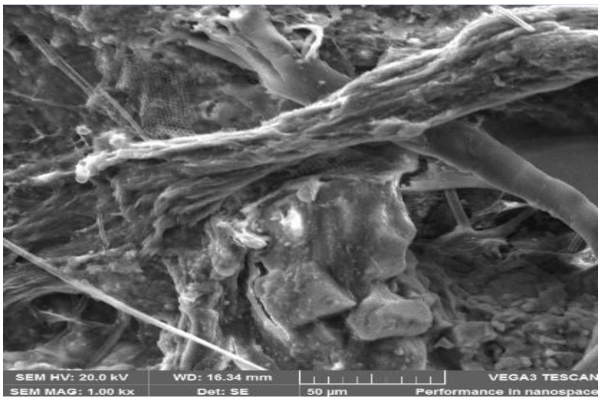

Fig. 2 The SEM image of the Morphology of the Scanned Sampled off the Coast of Lagos.

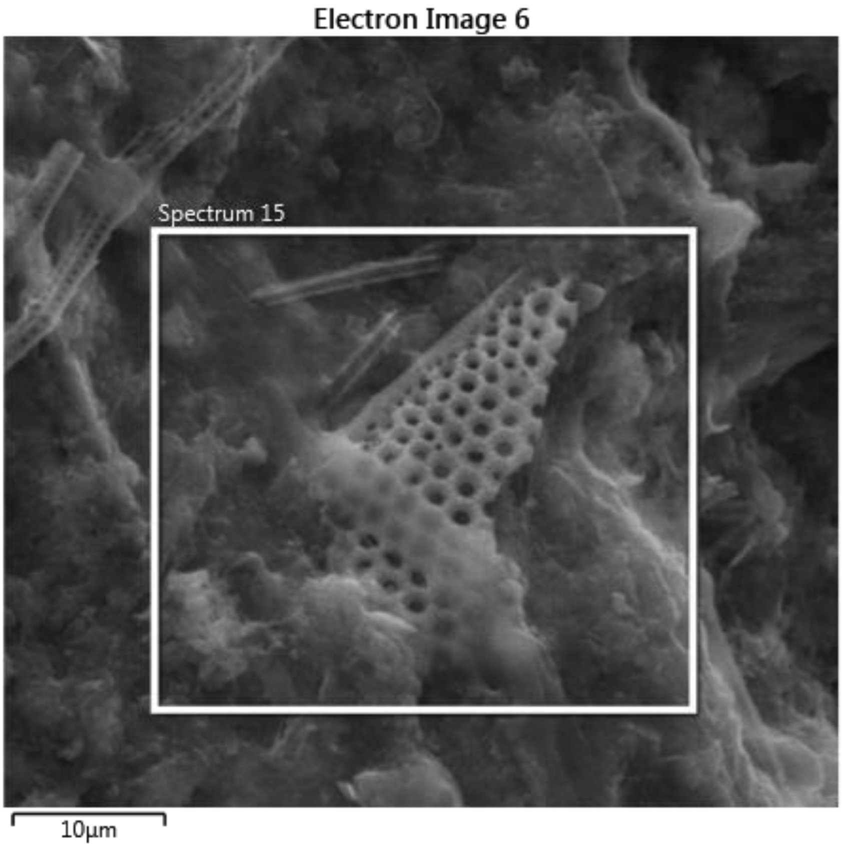

Fig. 3 SEM image of 10 µm plankton specimen off the coast of Lagos, Nigeria.

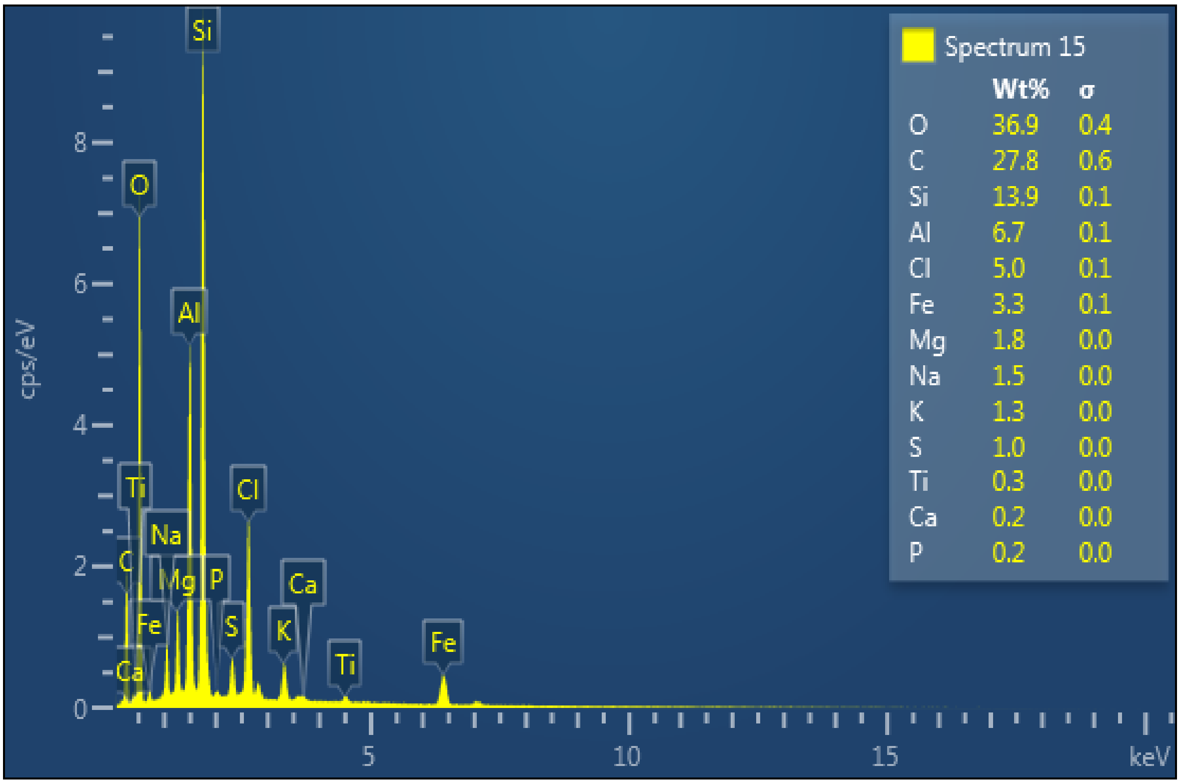

Fig. 4 X-ray Spectrum of the Elements in Plankton Specimen off the Coast of Lagos (EDS).

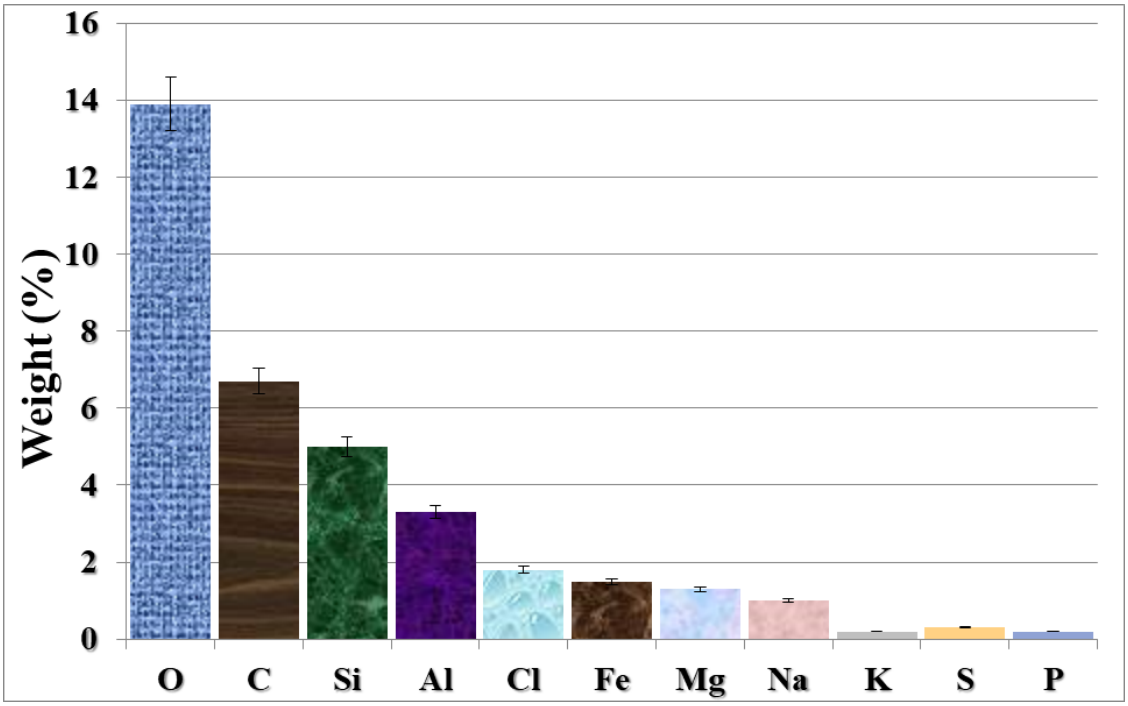

Fig. 5 Relative Levels of the Major Element Concentrations in the 100 μm Specimen off the Coast of Lagos, Nigeria (EDS).

DISCUSSION

The plankton from the Atlantic Ocean off the coast of Lagos was composed majorly of 13 elements oxygen (O), carbon (C), silicon (Si), aluminium (Al), chlorine (Cl), iron (Fe), magnesium (Mg), sodium (Na), potassium (K), sulphur (S), titanium (Ti), calcium (Ca) and phosphoru (P). Mineral or essential elements such as Ca, K, Na, Cl, Mg and Fe embedded in the plankton from this study have been reported to be responsible for the physiological processes of cells (White and Brown, 2010).

Previous studies of Yau *et al*., (2016) detected 12 elements of Y, Nb, Fe, Ca, Cl, K, Cu, F, Ir, P, Mg and Si within 16 cultured tropical microalgae species using SEM/EDS while Nekhoroshkov *et al*., (2014) reported concentration of 45 elements (Mg, Al, Cl, Ca, Ti, V, Mn, Cu, I, Na, K, Sc, Cr, Fe, Co, Ni, Zn, As, Se, Br, Rb, Sr, Zr, Mo, Ag, Sb, Cs, Ba, La, Ce, Nd, Sm, Gd, Tb, Tm, Yb, Hf, Ta, W, Au, Th, and U) determined by neutron activation analysis in plankton of the coastal zone of the Black Sea.

For this study, oxygen, carbon and silicon (78.6% by weight) were the most abundant element found in the sample. Organogenic elements such as O, C, S and P make up the total quantity or weight of living organisms. They form proteins, carbohydrates, lipids, nucleic acids and other biologically active compounds present in each cell of the phytoplankton (Nekhoroshkov *et al*., 2014). Additionally, Priyadarshani and Rath (2012) reported that microalgae were rich in elements such as Fe, Ca, K and Mg and these additional nutrients made them suitable for nutraceutical products such as *Chlorella* sp. and *Spirulina* sp. Also, Ca, Mg, K, Cl and Na have been reported by (Nekhoroshkov *et al*., 2014) to be the most abundant ions of seawater and by weight these ions constitute approximately 99% of sea salts while iron is the most important trace element that could increase phytoplankton production in ocean (Coale *et al*., 1996). However, the high concentration of these elements in the environment may slow down the vital processes, such as photosynthesis in the chloroplasts of phytoplankton cells (Nekhoroshkov *et al*., 2014).

It is important to note that the high amounts of Si (13.9% by weight) recorded in this study could be attributed to the presence of diatoms within the phytoplankton spectrum. It has been reported by Yau *et al*. (2016) that silicon is an essential element to diatoms and it is required in the construction of their disc-like frustules. According to Onyema and Akanmu (2017) diatoms are the dominant phytoplankton groups in the sea off the coast of Badagry Lagos from microscopic study. Conclusively, mineral elements recorded for this study include Ca, Mg, K, Cl and Na are the most abundant ions found in seawater. The organogenic elements of o, C, S and P as well as Al. Si, Fe and Ti are nutrients required to sustain life in the ocean.

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